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BALLISTICS RANGE TEST OF THE VIPER ROCKET: DATA REPORT.(U)
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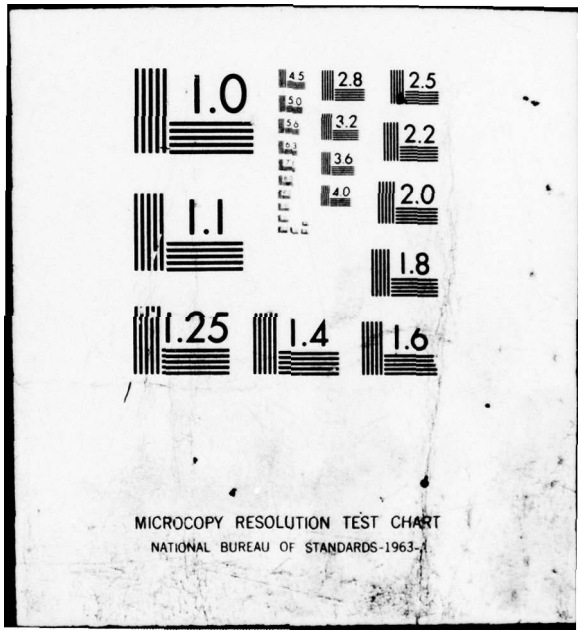
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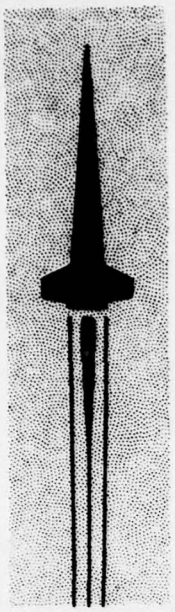

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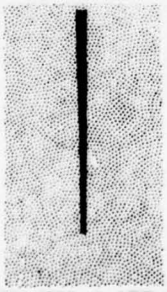

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LEVEL II

TECHNICAL REPORT T-79-9

BALLISTIC RANGE TEST OF THE VIPER ROCKET: DATA REPORT

George Batiuk
Systems Simulation Directorate
Technology Laboratory

11 October 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the data resulting from tests conducted at the Aeroballistics Research Facility, Eglin, Florida. Eleven missiles were fired, encompassing four different configurations, in an effort to determine the reason for the dispersion being experienced in live firing at the Redstone Arsenal test range.

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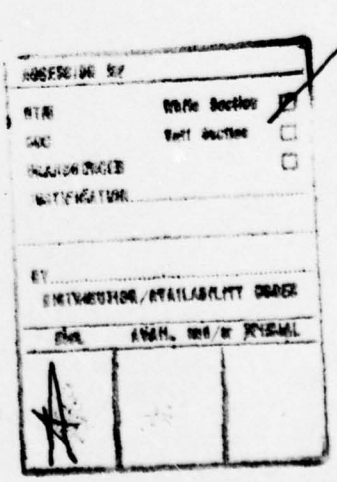
The Army wishes to acknowledge the fine performance of the staff of the Aeroballistic Research Facility, led by G. L. Winchenbach. Especially beneficial was the quick turn-around on the data reduction resulting in a rapid production of the aerodynamic coefficients desired by the Army. Ken West and his crew at the outdoor ballistic range, and Bill Lucas with his staff at the indoor range are to be commended for the timely and expert conduct of the tests described herein.

CONTENTS



ILLUSTRATIONS

TABLES

1. INTRODUCTION

VIPER is an unguided, anti-tank rocket being developed for the Army by General Dynamics.

Flight tests at Redstone Arsenal showed dispersions greater than desired or expected. Numerous simulation studies were conducted, using the aerodynamic coefficients obtained from the wind tunnel tests of September 1976. Various fixes were tried, e.g., shimming the fins in their retainers to reduce twisting and translational movements, sweeping the fins forward, etc. Since these efforts were not productive, it was decided to conduct a series of tests at the Aeroballistic Research Facility at Eglin Air Force Base, Florida, so that a fair amount of data could be obtained on various configurations under controlled, free-flight condition. General Dynamics of Pomona, California, conducted the tests.

Actual flight hardware was used and, since the missiles were inert, they were ballasted to the proper center of gravity location and weight. Several tests were conducted on the outdoor range to develop a suitable sabot before firing in the highly instrumented indoor ballistic range.

2. TEST FACILITY DESCRIPTION

The Aeroballistic Research Facility [1] is an enclosed, instrumented, concrete structure used to examine the exterior ballistics of various free-flight projectiles (*Figure 1*). The facility contains a gun room, control room, model measurements room, blast chamber, and the instrumented range.

The launcher used to propel the model is a high pressure air gun. Nitrogen gas under very high pressure is released suddenly and impinges on the sabot/model assembly thereby accelerating the model downrange at velocities approaching 1000 fps for these tests. As soon as the sabot is free of the gun barrel the air pressure forces its four segments to fly away from the model, leaving it unencumbered for its flight.

The 207 m instrumented length of the range has a 3.66 m square cross section for the first 69 m and a 4.88 m square cross section for the remaining length. The range has 131 locations available as instrumentation sites. Each location has a physical separation of 1.52 m and presently 50 of the sites are used to house fully instrumented orthogonal shadowgraph stations. The maximum shadowgraph window, an imaginary circle in which a projectile in flight will cast a shadow on both reflective screens is 2.13 m in diameter. A laser lighted photographic station is located in the uprange end of the instrumented range. This photographic station yields four orthogonal photographs, permitting a complete 360° view of the projectile as it passes the station on its downrange trajectory.

Four flash X-ray heads are located within the blast chamber. These flash X-ray heads can be combined to form four in-line or two orthogonal radiographic stations. These stations provide inspection photographs of model integrity and the model-sabot separation process as the model-sabot package exits the launcher muzzle.

All the instrumentation systems have been designed and installed in such a manner as to permit the stations to be movable. Therefore, any station can be moved to another instrumentation site in order to accommodate special test requirements. The present locations of the various stations are tabulated in *Table 1*.

The bullet catcher was placed just aft of station 25 for unproven models. Once confidence in the performance of the model was attained, the catcher was placed aft of station 42. A few intermediate shots were made with the catcher aft of station 35. The arbitrary "zero" of the instrumented portion of the range in 12 meters from the exit plane of the gun.

3. MODEL DESCRIPTION

Eleven models, comprising four different configurations, were tested. *Table 2* lists the various configurations tested, as well as their physical characteristics. *Figure 2* shows the basic VIPER configuration and the various fin configurations. Configuration 2, illustrated in *Figure 2*, is the baseline for this series of tests. It utilizes the basic VIPER missile with the fins swept forward 10° and shimmed tightly at the root. The fins for configuration 3, depicted in *Figure 4*, were increased approximately 10% in area, had 5° forward sweep, and as shown in *Figure 2*, incorporated a design labelled "root control." This consisted of shaving off a portion of the fin at the root in an effort to force all fins to twist in the same direction. Configuration 7 is the same as 3 but with the centerbody faired in.

Configuration 12, shown in *Figure 4*, is the wrap-around design used in earlier programs. A nozzle and fin assembly from the LAW program was accurately assembled to the VIPER motor case from which the nozzle assembly had been removed.

Figure 5 shows the sabot and fin fairing sections as they are assembled to the missile. *Figure 6* is a shot of the assembly ready for installation in the gun, showing the fins in an almost extended position inside the fin fairing. And finally, *Figure 7* illustrates the loading procedure.

4. DATA

The shadowgrams obtained during a test program are read and coded for utilization in specialized computer programs run on a CDC 6600. Aerodynamic coefficients are extracted from the model's measured time,

position and attitude histories obtained from the shadowgrams. Both linear theory data reduction and non-linear numerical integration techniques are utilized in this procedure. *Table 3* contains the computer printouts that were produced.

Table 4 lists the aerodynamic coefficients obtained for the four VIPER configurations tested. *Table 5* compares the aerodynamic coefficients obtained from the VIPER wind tunnel tests of 1976 [2] with those of the tests described herein.

A partial explanation for the disparity of the various coefficients lies in the slight difference in the fin set-up of the two models. The Eglin model incorporated a 10° forward sweep in the fin assembly, and was not shimmed as tightly as the wind tunnel model.

TABLE 1. LOCATIONS OF RANGE INSTRUMENTATION

Unit	Description	Nominal Longitudinal Distance from Range Origin (m)
X-ray No. 1	Two orthogonal views	-8 to -14
X-ray No. 2	(or four single plan)	-6 to -12
S.G. No. 1	Two orthogonal views	2.0
S.G. No. 2		3.5
S.G. No. 3		5.0
S.G. No. 4		8.1
Laser No. 1	Four orthogonal views	9.6
S.G. No. 5	Two orthogonal views	14.2
S.G. No. 6		17.2
S.G. No. 7		20.3
S.G. No. 8		21.8
S.G. No. 9		23.3
Multi. S.G. No. 1	One plane, four photos	26.4
S.G. No. 10	Two orthogonal views	29.4
S.G. No. 11		35.5
S.G. No. 12		38.6
S.G. No. 13		41.6
S.G. No. 14		44.7
S.G. No. 15		47.7
S.G. No. 16		52.3
S.G. No. 17		55.3
S.G. No. 18		58.4
S.G. No. 19		64.4
S.G. No. 20		67.5
S.G. No. 21		70.5
S.G. No. 22		73.7
S.G. No. 23		76.6
S.G. No. 24		79.6
S.G. No. 25		82.7
S.G. No. 26		84.2
S.G. No. 27		88.8
S.G. No. 28		93.4
S.G. No. 29		98.0
S.G. No. 30		102.5
S.G. No. 31		107.1
S.G. No. 32		116.3
S.G. No. 33		120.9
S.G. No. 34		125.4
S.G. No. 35		130.0
S.G. No. 36		134.6

TABLE 1. (CONCLUDED)

Unit	Description	Nominal Longitudinal Distance from Range Origin (m)
S.G. No. 37	One Plane, four photos	139.2
S.G. No. 38	Two orthogonal views	143.7
S.G. No. 39	↓	148.3
S.G. No. 40	↓	152.9
S.G. No. 41	↓	157.5
S.G. No. 42	↓	162.0
S.G. No. 43	↓	166.6
S.G. No. 44	↓	171.2
S.G. No. 45	↓	178.8
S.G. No. 46	↓	183.4
S.G. No. 47	↓	188.0
S.G. No. 48	↓	192.5
S.G. No. 49	↓	197.1
S.G. No. 50	↓	201.7

Note: Gun exit plane was approximately 32.2 feet uprange from range origin (m).

TABLE 2. MODEL CONFIGURATIONS AND CHARACTERISTICS

CONFIGURATION NUMBER	SET NUMBER*	SHOT NUMBER**	MASS (GMS)	XCG MM FROM NOSE	MODEL LENGTH MM	IY GM-CM-SEC^2	IX GM-CM-SEC^2	ROLL UNBALANCE GM/CM	CONFIGURATION (GENERAL)
2	112	93	1412.1	299.85	648.08	282.148	10.019	22.966	Baseline
2	113	94	1437.2	297.08	647.72	287.544	10.230	3.671	Fins swept forward 10° Fins shimmed
2	114	95	1424.4	298.09	648.26	285.684	10.116	14.917	
3	115	96	1427.4	295.64	648.20	287.759	10.286	24.321	Max area
3	178	97	1420.5	297.79	648.31	285.802	10.229	45.639	Root Control
3	179	98	1417.9	297.53	648.28	287.396	10.191	8.053	Fins swept forward 5°
12	263	99	1500.00	293.09	657.00	344.175	10.658	64.658	
12	265	2	1498.1	294.89	658.22	344.705	-	57.583	Wrap-around fins (LAW fins and nozzle installed on VIPER Body)
12	266	1	1493.1	294.69	657.83	342.041	10.583	11.377	
7	224	9	1447.0	296.60	648.46	294.666	11.026	15.593	
7	228	8	1426.1	299.62	647.98	286.188	10.713	18.111	Baseline with faired centerbody

*General Dynamics designation
**Eglin designation

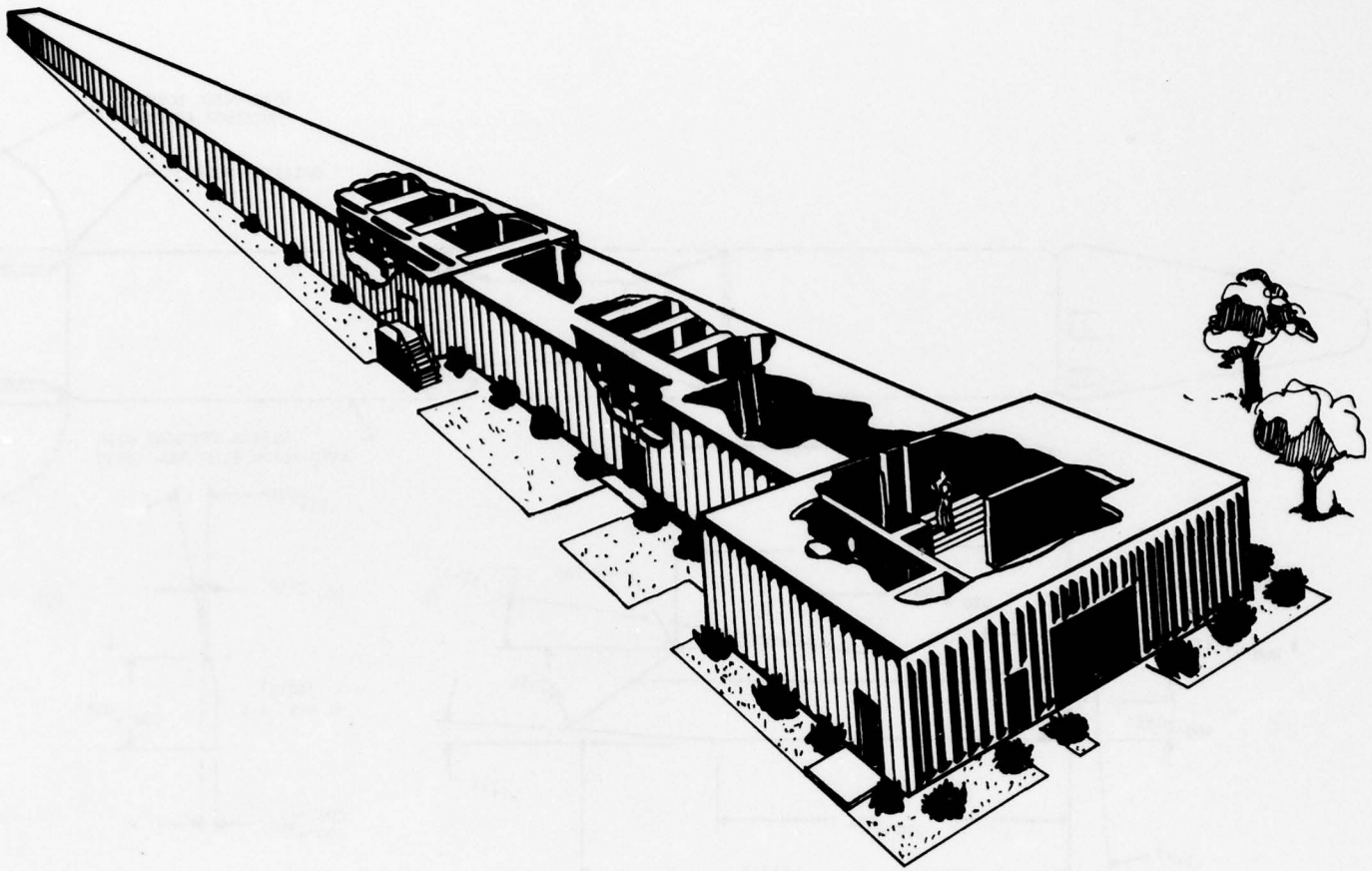


Figure 1. Aeroballistic research facility. Artist's conception

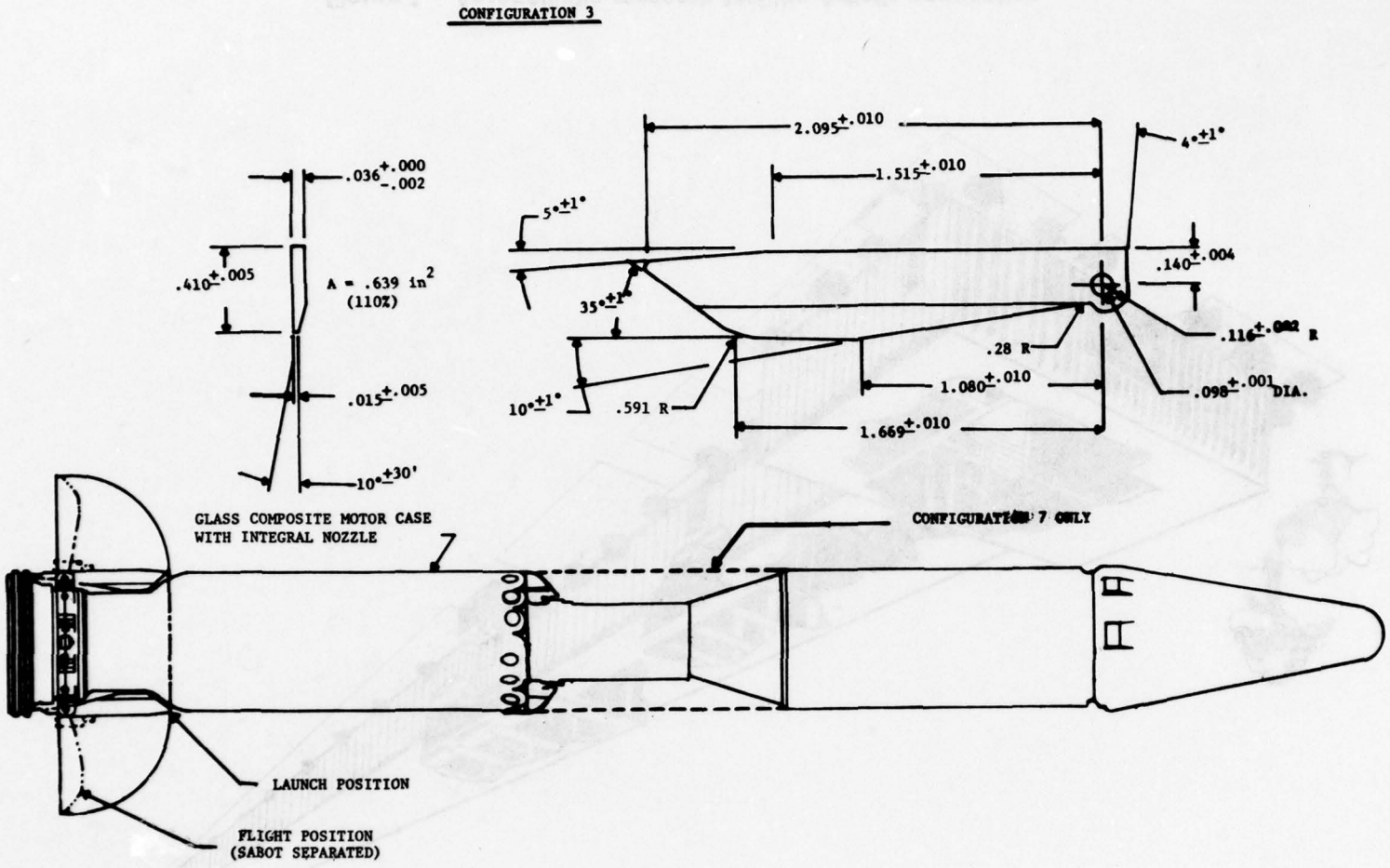
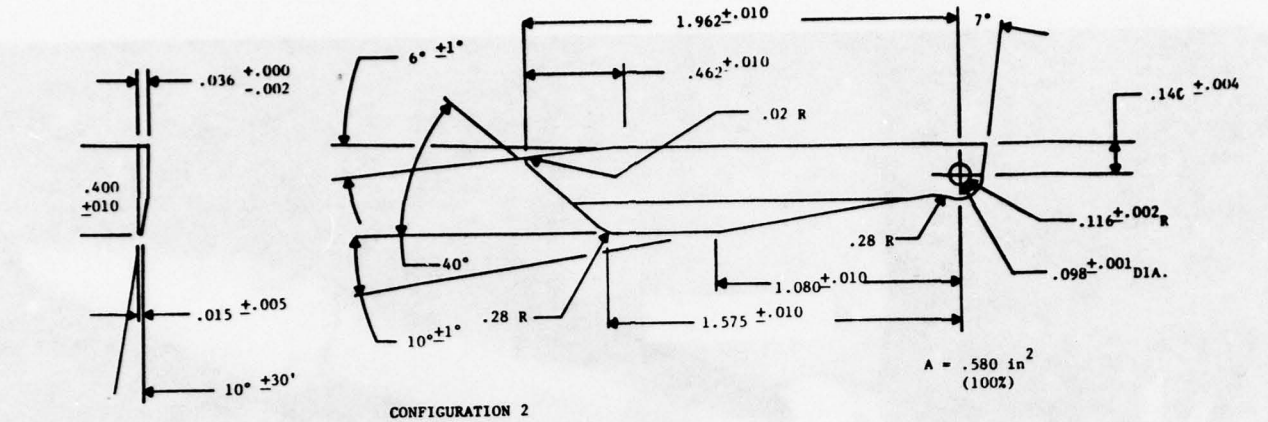
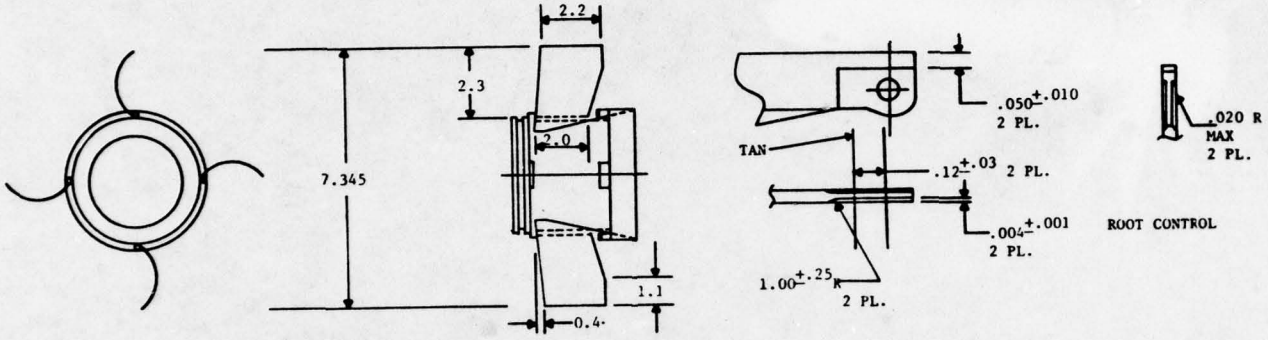


Figure 2. Outline of VIPER and all fin configurations.



CONFIGURATION 2



CONFIGURATION 12

Figure 2. (Concluded)

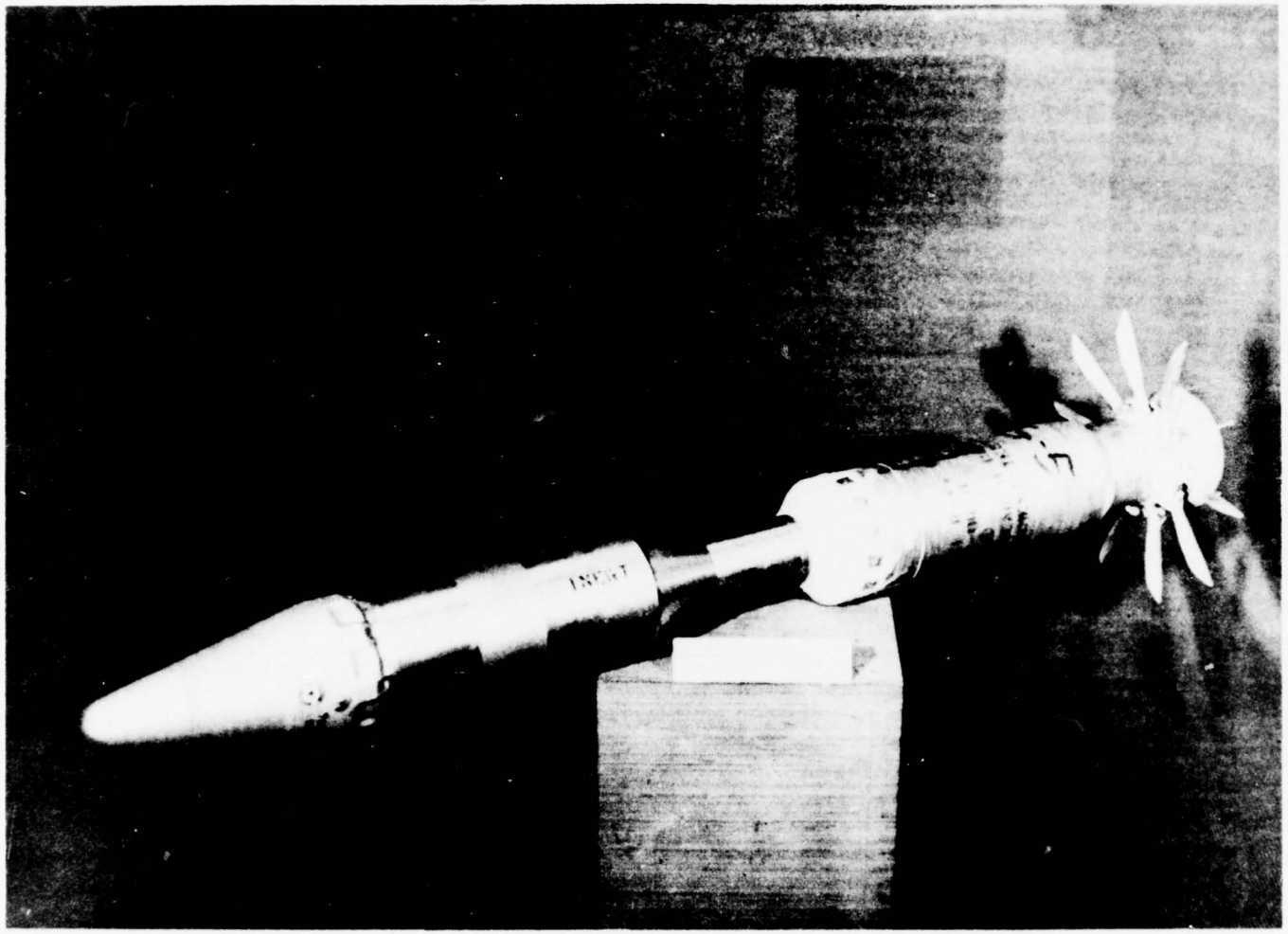
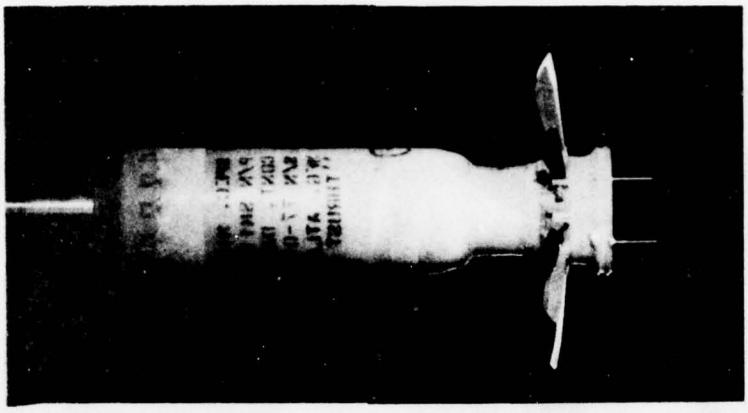
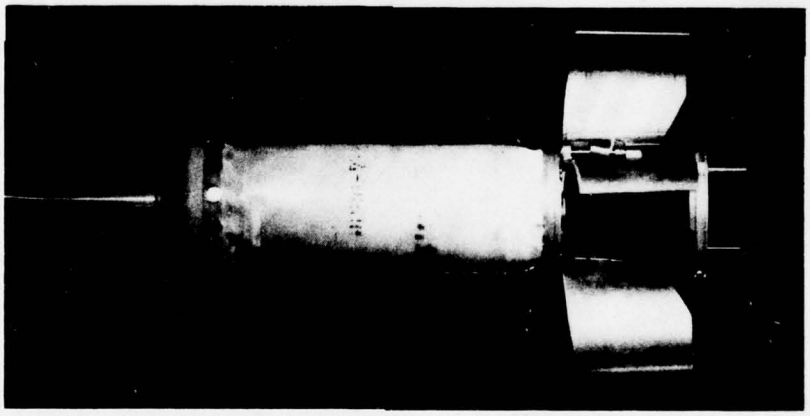


Figure 3. Typical VIPER round.



(a) Configuration 3



(b) Configuration 12

Figure 4. VIPER in flight at the laser station.

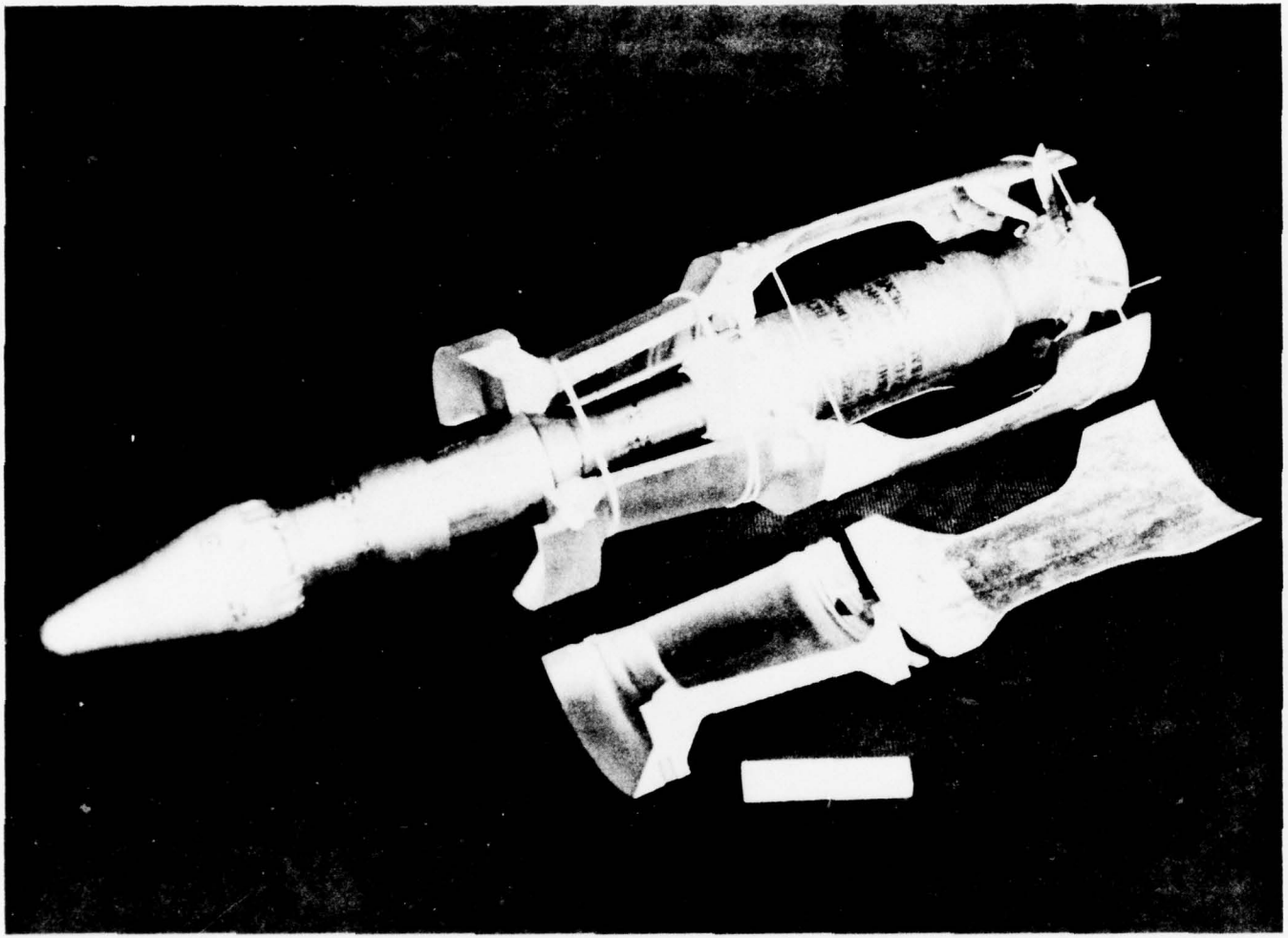


Figure 5. VIPER/sabot assembly—one section of sabot and fin fairing removed.

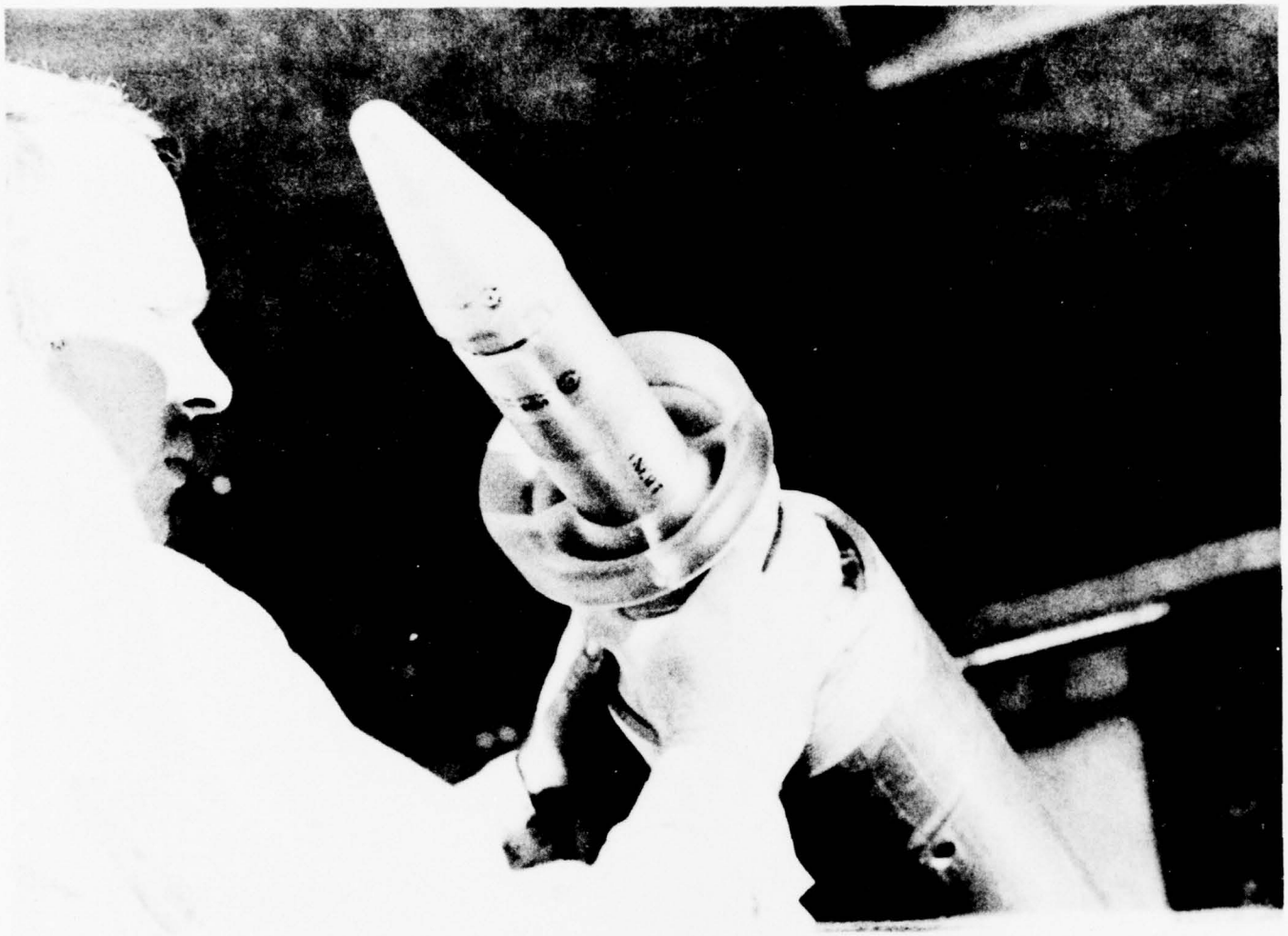


Figure 6. VIPER ready for launch, showing fin protector plates holding fins in launch position (partially deployed).

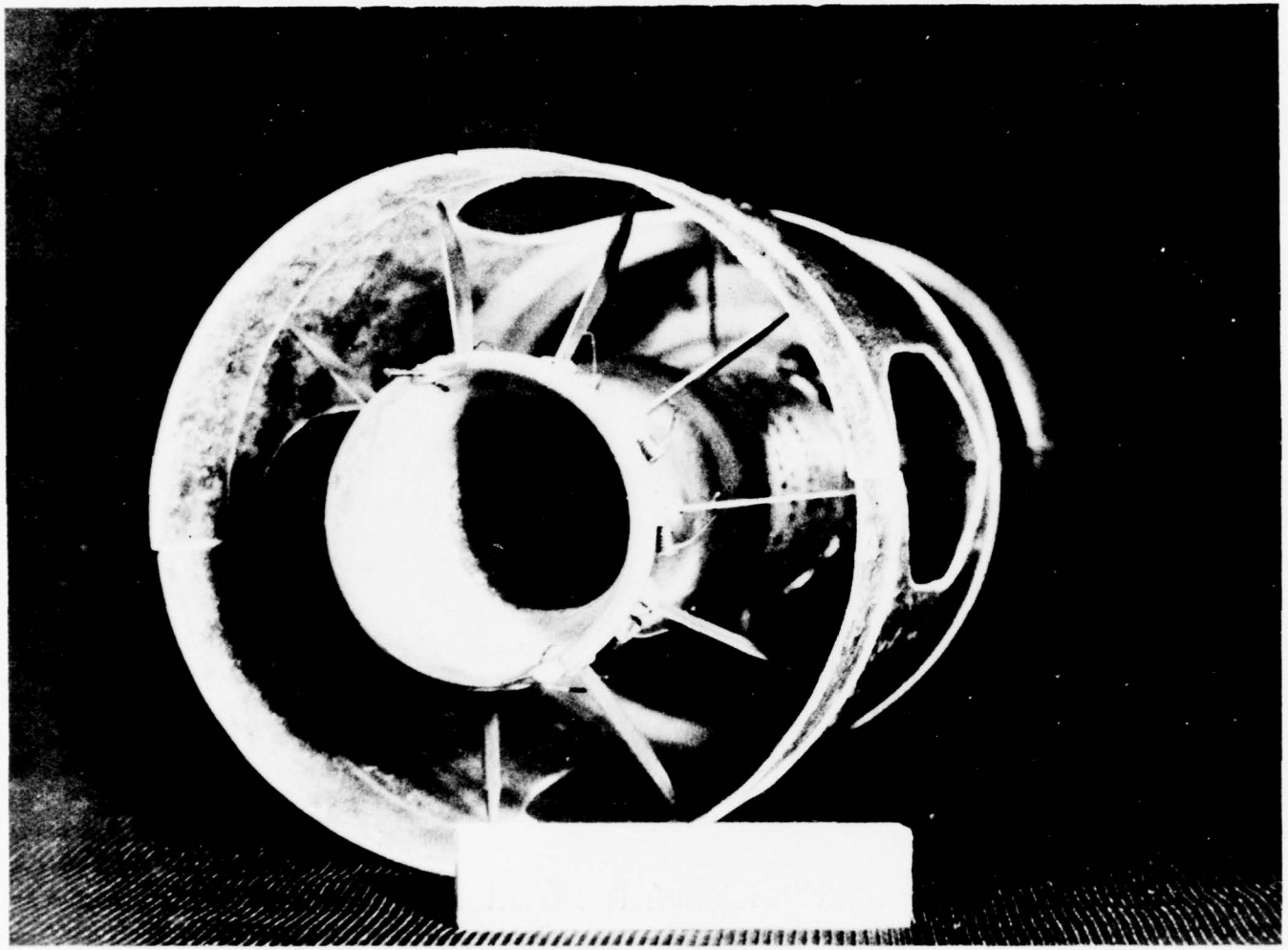


Figure 7. Installation of VIPER/sabot in ballistic gun barrel.

TABLE 3. VIPER AERO DATA

SHOT 096

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4244331	55.4984	30.8431	6.7235	.00736	.00148	269.27	-.72454668	989.96343817
.4546094	55.7719	31.2657	16.7736	.02086	-.01145	287.10	.72226674	986.43370917
.4447707	56.1338	31.7288	26.7829	.02464	-.00769	310.25	-.72001108	982.94178013
.4651925	57.0971	32.3546	46.7885	-.01537	.01283	11.45	-.71554706	976.03172327
.4754433	57.4928	32.6568	56.7679	-.01586	.00829	48.19	-.71334209	972.61884169
.4857426	57.8316	32.9787	66.7770	-.00133	.00148	89.79	-.71114496	969.21828032
.4908789	58.0668	33.0232	71.7612	.01651	-.00518	111.53	-.71005619	967.53324083
.4960585	58.1688	33.1356	76.7570	.02210	-.00749	134.40	-.70896843	965.84979926
.5377987	60.0166	33.5246	116.7863	-.01469	-.01237	316.58	-.70037839	952.55738757
.5588582	60.7166	33.4301	136.7825	.02652	.00531	49.11	-.69616933	946.04532871
.5694453	61.1128	33.2438	146.7841	.02148	.02028	96.94	-.69408411	942.81944526
.5800592	61.6253	33.1692	156.7716	-.00442	.01209	143.58	-.69201499	939.61866297
.5960874	62.2383	33.0049	171.7885	-.03033	-.02336	217.14	-.68892842	934.84429356
.6068073	62.6406	32.7455	181.7930	-.00375	-.01931	265.09	-.68688825	931.68873675
.6175489	62.9491	32.3211	191.7830	.01488	.00114	313.30	-.68486377	928.55764395
.6388971	63.7359	31.6844	211.5468	.00732	.01407	50.88	-.68089567	922.42105047
.6497435	64.2064	31.2542	221.5362	.00254	-.02394	102.05	-.67890853	919.34824259
.6606512	64.5934	30.7696	231.5396	.00024	-.04055	152.34	-.67693090	916.29031309
.6827219	65.4641	29.4079	251.7058	-.00959	.01900	248.88	-.67298104	910.18336630
.7045613	66.2131	27.8792	271.5174	.00909	.00502	341.09	-.66914798	904.25768776
.7101351	66.3648	27.6102	276.5512	.01645	-.00353	43.95	-.66818143	902.76357693
.7267967	66.9658	26.4449	291.5561	.02521	-.02704	114.43	-.66531782	898.33721356
.7435265	67.8064	25.1181	306.5477	-.00776	-.01472	184.96	-.66248266	893.95520859
.7604436	68.5710	23.5187	321.6332	-.02368	.00431	257.50	-.65965552	889.58599893
.7773719	69.0885	21.8984	336.6533	.01177	.00749	329.20	-.65686598	885.27529279
.7944082	69.7184	20.4311	351.6987	.03786	-.01356	359.29	-.65409675	880.99636636

TABLE 3.

SHOT 094

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4257037	55.6756	31.8078	7.0363	-.00950	.01628	28.93	-.72461539	991.47775816
.4358578	55.9837	32.5842	17.0791	.00094	-.00055	39.10	-.72147496	987.96074278
.4460111	56.2291	33.3343	27.0977	.00903	-.00857	52.34	-.71836621	984.47971443
.4663967	56.8995	34.5965	47.0941	.00682	-.00023	86.39	-.71223230	977.61272754
.4766247	57.2890	35.0705	57.0698	.00665	.00257	107.19	-.70920702	974.22664250
.4869846	57.5957	35.5474	67.0816	.00546	.00829	129.33	-.70619373	970.85445755
.4920305	57.7465	35.7969	72.0467	.00743	.00585	140.87	-.70470780	969.19173391
.4972030	57.9061	36.0132	77.0575	.00871	.00933	152.90	-.70321383	967.52012818
.5388623	59.6338	37.5231	117.0834	.00423	.01164	263.53	-.69147927	954.39472563
.5598614	60.5484	38.0965	137.0641	-.01553	-.00011	324.99	-.68575074	947.99010876
.5704311	60.9435	38.3383	147.0629	-.01312	-.00464	358.63	-.68291553	944.82101633
.5810105	61.2816	38.5071	157.0467	-.00399	-.00139	29.12	-.68010523	941.68023545
.5969920	61.7170	38.6636	172.0513	.01159	.00071	81.40	-.67591995	937.00367834
.6076979	62.0797	38.7401	182.0697	.01808	-.00073	114.80	-.67315076	933.91004347
.6184115	62.4953	38.7885	192.0531	.01451	.00075	149.11	-.67041114	930.84990331
.6397027	63.3103	38.7574	211.8129	.00724	.01541	218.71	-.66504636	924.85888708
.6505217	63.7537	38.7063	221.8005	.00068	.01634	254.06	-.66236348	921.86351998
.6613893	64.2129	38.5839	231.8081	-.00176	.00641	290.75	-.65969429	918.88392767
.6723677	64.6469	38.5101	241.8800	-.00042	-.00618	327.41	-.65702704	915.90696005
.6833964	65.0276	38.4143	251.9661	-.00041	-.01225	4.37	-.65437499	912.94744523
.6941894	65.4216	38.2013	261.7987	.00307	-.01633	40.78	-.65180768	910.08294708
.7051694	65.8908	37.8296	271.7744	.00800	-.01999	77.81	-.64922105	907.19735788
.7107247	66.1244	37.6760	276.8118	.00661	-.01833	96.61	-.64792174	905.74804454

TABLE 3.

SHOT 095

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4540415	55.6019	30.7283	6.7534	-.04317	.02735	155.46	-.70996137	993.69381631
.4641745	55.6447	31.3939	16.8014	-.01633	-.00233	162.75	-.70824657	990.21098771
.4742938	55.7042	32.0431	26.8109	.01741	-.02001	172.14	-.70654756	986.76194872
.4946289	56.1256	32.8169	46.8150	.03671	-.01798	198.97	-.70317938	979.92945425
.5048368	56.4742	33.0031	56.7919	.01949	-.00011	215.42	-.70151297	976.55157403
.5150969	56.9117	33.1658	66.8090	.00557	.01779	233.48	-.69984875	973.17979734
.5202096	57.1159	33.2567	71.7815	-.00124	.02072	243.06	-.69902592	971.51332881
.5253709	57.3531	33.3363	76.7884	-.00891	.02184	253.38	-.69819959	969.84018802
.5669388	58.8907	34.1228	116.8184	.02108	-.00040	347.69	-.69167124	956.63628231
.5879044	59.8388	34.1586	136.8064	.01465	-.00821	41.61	-.68846252	950.15615056
.6090128	60.9424	33.9764	156.7989	-.00963	.00450	99.79	-.68528637	943.74817161
.6249759	61.6344	33.7743	171.8148	-.01241	.00581	144.96	-.68292241	938.98295334
.6356469	62.0664	33.6308	181.8215	-.00020	.00629	174.88	-.68135720	935.82980802
.6463400	62.4925	33.4279	191.8089	.01162	-.00402	206.56	-.67980303	932.70046147
.6675969	63.4350	32.9420	211.5709	.02504	-.00797	270.11	-.67675118	926.56004647
.6783949	63.9130	32.5683	221.5566	.01681	-.00898	303.28	-.67522077	923.48310035
.6892551	64.5970	32.1398	231.5647	.00552	-.00290	334.74	-.67369471	920.41644146
.7002166	65.1814	31.6853	241.6485	-.00197	.00382	8.77	-.67216494	917.34385091
.7112257	65.7566	31.1934	251.7329	-.00869	.00467	44.04	-.67064286	914.28826848
.7329715	66.7691	30.1011	271.5451	.00074	-.00508	112.53	-.66767499	908.33468675
.7385191	67.0208	29.8593	276.5831	.00400	-.00714	129.93	-.66692500	906.83113619
.7717552	68.6163	27.8538	306.5724	.01157	.00092	237.12	-.66249950	897.96684210
.7885956	69.4553	26.7395	321.6594	.00508	.00106	291.13	-.66029798	893.56219640
.8054380	70.2647	25.6008	336.6784	-.00186	-.00166	346.37	-.65812267	889.21326487
.8223968	71.0469	24.2699	351.7251	-.01214	-.01030	40.48	-.65595944	884.89176992
.8565666	72.1588	21.3979	381.8229	.00407	-.01363	198.69	-.65167998	876.35235569
.8737214	72.7238	19.6838	396.8159	.01086	-.01989	206.11	-.64957153	872.14986324
.8909864	73.1978	18.0919	411.7951	.00597	-.01494	261.25	-.64748029	867.98481733

TABLE 3.

SHOT 096

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4244331	55.4984	30.8431	6.7235	.00736	.00148	269.27	-.72454668	989.96343817
.4546094	55.7719	31.2657	16.7736	.02086	-.01145	287.10	.72226674	986.43370917
.4447707	56.1338	31.7288	26.7829	.02464	-.00769	310.25	-.72001108	982.94178013
.4651925	57.0971	32.3546	46.7885	-.01537	.01283	11.45	-.71554706	976.03172327
.4754433	57.4928	32.6568	56.7679	-.01586	.00829	48.19	-.71334209	972.61884169
.4857426	57.8316	32.9787	66.7770	-.00133	.00148	89.79	-.71114496	969.21828032
.4908789	58.0668	33.0232	71.7612	.01651	-.00518	111.53	-.71005619	967.53324083
.4960585	58.1688	33.1356	76.7570	.02210	-.00749	134.40	-.70896843	965.84979926
.5377987	60.0166	33.5246	116.7863	-.01469	-.01237	316.58	-.70037839	952.55738757
.5588582	60.7166	33.4301	136.7825	.02652	.00531	49.11	-.69616933	946.04532871
.5694453	61.1128	33.2438	146.7841	.02148	.02028	96.94	-.69408411	942.81944526
.5800592	61.6253	33.1692	156.7716	-.00442	.01209	143.58	-.69201499	939.61866297
.5960874	62.2383	33.0049	171.7885	-.03033	-.02336	217.14	-.68892842	934.84429356
.6068073	62.6406	32.7455	181.7930	-.00375	-.01931	265.09	-.68688825	931.68873675
.6175489	62.9491	32.3211	191.7830	.01488	.00114	313.30	-.68486377	928.55764395
.6388971	63.7359	31.6844	211.5468	.00732	.01407	50.88	-.68089567	922.42105047
.6497435	64.2064	31.2542	221.5362	.00254	-.02394	102.05	-.67890853	919.34824259
.6606512	64.5934	30.7696	231.5396	.00024	-.04055	152.34	-.67693090	916.29031309
.6827219	65.4641	29.4079	251.7058	-.00959	.01900	248.88	-.67298104	910.18336630
.7045613	66.2131	27.8792	271.5174	.00909	.00502	341.09	-.66914798	904.25768776
.7101351	66.3648	27.6102	276.5512	.01645	-.00353	43.95	-.66818143	902.76357693
.7267967	66.9658	26.4449	291.5561	.02521	-.02704	114.43	-.66531782	898.33721356
.7435265	67.8064	25.1181	306.5477	-.00776	-.01472	184.96	-.66248266	893.95520859
.7604436	68.5710	23.5187	321.6332	-.02368	.00431	257.50	-.65965552	889.58599893
.7773719	69.0885	21.8984	336.6533	.01177	.00749	329.20	-.65686598	885.27529279
.7944082	69.7184	20.4311	351.6987	.03786	-.01356	359.29	-.65409675	880.99636636

TABLE 3.

SHOT 097

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4542648	55.4524	30.3628	26.8059	.02769	.04002	349.18	-.72992593	986.16026814
.4745099	56.[illegible]859	30.6998	46.8114	-.00510	-.01159	38.62	-.72547027	979.20431824
.4950909	56.5748	30.7111	66.8028	-.00146	-.01841	100.24	-.72107527	972.34410850
.5002121	56.6675	30.5827	71.7784	.00187	.00059	116.49	-.71999023	970.65059800
.5053761	56.7900	30.4101	76.7854	.00817	.01843	132.70	-.71890184	968.95194119
.5469806	57.9434	30.1073	116.8138	-.00483	-.03919	273.38	-.71032529	955.56869979
.5679750	58.3951	29.3776	136.8072	-.00725	-.00572	346.02	-.70612267	949.01223619
.5785286	58.5698	28.8841	146.8008	-.00074	.01779	26.02	-.70404184	945.76632609
.5891088	58.7802	28.4966	156.7965	.00717	.01824	69.13	-.70197362	942.54034271
.6050928	59.1414	27.8745	171.8111	.01934	-.01897	135.64	-.69889121	937.73288028
.6157786	59.4457	27.4373	181.8183	.00565	-.01649	180.88	-.69685279	934.55397900
.6477719	60.2237	25.5433	211.5638	.01049	.00415	324.56	-.69086804	925.22225133
.6585797	60.3644	24.8901	221.5494	.00984	-.00231	14.02	-.68888350	922.12831975
.6694632	60.4848	24.1302	231.5609	.02689	-.01367	65.47	-.68690599	919.04561245
.6804320	60.7018	23.3015	241.6279	.02493	-.01589	115.95	-.68492973	915.96507067
.6914629	61.0532	22.3666	251.7329	.01057	-.00893	167.38	-.68295819	912.89213862
.7132375	61.8613	20.5014	271.5355	-.02293	-.00043	271.05	-.67912956	906.92537930
.7187944	61.9853	19.9650	276.5693	-.01983	-.00966	298.25	-.67816364	905.42016700
.7354039	62.2193	18.4706	291.5749	.00579	-.02021	16.25	-.67530160	900.[illegible]6057759
.7520839	62.5373	16.7440	306.5737	.03200	-.01979	91.31	-.67246656	896.54358422
.7689466	63.0996	14.7822	321.6501	.00946	-.00677	170.37	-.66964240	892.14406656
.7858164	63.6904	12.7533	336.6727	-.02182	-.00432	246.06	-.66685345	887.79[illegible]92248
.8028015	64.0714	10.6271	351.7092	-.01001	-.01624	329.99	-.66408670	883.49[illegible]38434
.8370381	64.9255	6.1463	381.8155	.03043	-.00460	114.34	-.65862030	874.97882544
.8542244	65.6955	3.7395	396.8153	.00005	-.00237	186.61	-.65593258	870.79439255
.8715169	66.4010	2.0511	411.7664	-.01561	-.00402	267.17	-.65327687	866.66029186
.8888846	67.0293	-1.2918	426.8523	-.00646	-.02196	343.06	-.65062047	862.52561496
.9064081	67.5999	-3.8010	441.9366	.01585	-.01504	60.29	-.64798740	858.42775063
.9238912	68.1339	-6.7311	456.8979	.01880	-.00091	138.06	-.64539826	854.39876163

TABLE 3.

SHOT 098

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ	C_{DT}	V-fps
.4726062	55.7365	31.4439	26.8074	.01716	-.01328	339.27	-.72158378	986.62277896
.4929481	56.3252	32.0722	46.8101	-.01576	.00666	29.76	-.71803865	979.72913083
.5031586	56.5792	32.3568	56.7965	-.01644	.01439	61.45	-.71628332	976.31807832
.5134182	56.7775	32.6252	66.8083	.00188	.00342	94.92	-.71453316	972.91858544
.5185354	56.7943	32.7639	71.7857	.01318	-.00170	111.81	-.71366663	971.23600256
.5236941	56.8782	32,8399	76.7914	.02185	-.00895	129.64	-.71279755	969.54883879
.5652710	57.9580	32.9420	116.8128	-.00862	-.00011	270.04	-.70593356	956.23693386
.5862502	58.3198	32.7085	136.8077	.03184	.00702	339.45	-.70255951	949.70211158
.5967979	58.7235	32.5163	146.8070	.01556	.00070	15.68	-.70088571	946.46248761
.6073673	59.1320	32.3281	156.8001	-.01645	-.01526	53.38	-.69922187	943.24357335
.6233420	59.5282	31.8767	171.8175	-.02597	-.02279	107.39	-.69673810	938.44107777
.6340178	59.6734	31.4363	181.8223	.00331	-.00191	141.63	-.69509434	935.26456759
.6447178	59.8643	30.8854	191.8071	.02292	.01393	174.16	-.69346252	932.11255022
.6659884	60.3765	29.9856	211.5699	-.01265	-.02349	240.99	-.69025792	925.92665233
.6767944	60.6525	29.4522	221.5547	-.01312	-.04072	275.15	-.68865146	922.82775021
.6876640	60.8263	28.7368	231.5665	.00301	-.02131	308.94	-.68704906	919.73807648
.6986224	61.0426	27.9078	241.6387	.01036	.02124	340.23	-.68544542	916.64740861
.7096466	61.2623	27.1434	251.7315	-.00089	.04340	13.90	-.68384692	913.56802639
.7204235	61.4552	26.4717	261.5540	-.01670	.02072	46.90	-.68229924	910.58789956
.7314073	61.6066	25.8534	271.5444	-.01514	-.02038	80.08	-.68073316	907.57367852
.7369616	61.6311	25.4996	276.5818	-.00927	-.04291	96.56	-.67994656	906.06023521
.7535659	61.7509	24.2412	291.5895	.01806	-.02484	146.65	-.67761514	901.57652618
.7702290	61.9484	22.6483	306.5728	.00503	.02149	198.40	-.67530535	897.13743143
.7870801	62.2848	21.2278	321.6581	-.01450	-.00436	251.64	-.67299763	892.70533828
.8039419	62.4176	19.7779	336.6756	.01067	-.03756	304.02	-.67071782	888.32981475
.8209142	62.6173	17.8690	351.7141	.02023	.00682	354.29	-.66845214	883.98437711
.8551255	63.3167	14.4630	381.8135	-.02458	-.01907	96.92	-.66396864	875.39412771
.8723078	63.4217	12.4869	396.8175	.01276	-.04801	147.48	-.66175884	871.16454880
.8895908	63.5628	10.7176	411.7791	.02697	-.00740	197.10	-.65957167	866.98115890
.9244499	64.3425	5.7043	441.9030	-.01707	-.01886	299.08	-.65521690	858.66035757
.9419347	64.5252	3.2376	456.8941	.02179	-.03131	349.29	-.65307374	854.56957796
.9595821	64.7584	.5143	471.9369	.01602	.02346	39.47	-.65093897	850.49760680
.9773074	65.1132	-2.2555	486.9773	-.02294	.01804	87.82	-.64882016	846.45886890
.9950668	65.3947	-4.5026	501.9478	-.01444	-.03611	141.20	-.64672653	842.47088229
1.0309076	65.6573	-10.6836	532.0162	.01927	.00657	243.74	-.64256700	834.55590092

TABLE 3.

SHOT 099

T-SEC	Y-IN	Z-IN	X-FT	M	N	Ø- DEG	C_{DT}	V-fps
.4134479	55.8060	30.6838	11.6835	.00906	.00814	72.75	-.75822690	978.07354471
.4288423	56.2782	31.1094	26.7032	.01885	.01711	73.64	-.75342848	972.85541727
.4494777	57.2007	31.7379	46.7070	.01497	.01452	94.82	-.74712284	965.99950777
.4548385	57.7433	31.9885	56.6875	.01379	.01347	111.60	-.74401236	962.61812659
.4702446	58.2790	32.2625	66.7014	.00805	.01561	133.32	-.74091525	959.25164368
.4754365	58.6098	32.4178	71.6761	.00673	.01288	145.10	-.73938530	957.58874718
.4806683	58.9031	32.4933	76.6802	.00031	.01180	158.15	-.73785207	955.92238375
.5016982	60.0233	32.9958	96.7085	-.01263	.00309	217.93	-.73177278	949.31611020
.5228425	60.8838	33.2566	116.7150	-.00779	-.00484	289.92	-.72579008	942.81621051
.5441197	61.5856	33.3435	136.7065	.01053	-.00620	10.95	-.71989970	936.41800423
.5548152	61.9914	33.2242	146.6993	.01507	-.00337	54.79	-.71698767	933.25545672
.5655353	62.4646	33.1157	156.7003	.01908	.00681	100.23	-.71409450	930.11373085
.5817257	63.1651	32.8620	171.7076	.00061	.00887	170.88	-.70979242	925.44271015
.5925562	63.6985	32.7384	181.7215	-.01201	.00785	219.71	-.70694772	922.35448358
.6249669	64.8488	32.0149	211.4702	-.00058	-.01420	11.52	-.69861689	913.31251720
.6359207	65.0608	31.5702	221.4557	.00690	-.00996	64.19	-.69586010	910.32107784
.6469346	65.4048	31.0869	321.4648	.01395	.00056	117.94	-.69311638	907.34417076
.6580455	65.6888	30.4804	241.5307	-.00035	.00610	172.10	-.69037667	904.37194913
.6912750	66.5020	28.8946	271.4327	-.00780	-.01168	339.99	-.68235171	895.66797545
.6969065	66.5873	28.5942	276.4779	.00070	-.01578	8.38	-.68101421	894.21760613

TABLE 3.

SHOT 001

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4456478	56.5142	30.3216	26.7767	.00407	.03906	332.59	-.79496890	989.17346493
.4659277	57.3148	30.6356	46.7768	.00318	.06818	25.10	-.79005598	981.79887172
.4761206	57.6988	30.9981	56.7602	.00735	.05354	50.63	-.78762810	978.15521465
.4863576	58.1409	31.4796	66.7658	.01577	.03249	76.65	-.78521097	974.52817467
.4914681	58.2902	31.7986	71.7408	.01461	.02235	91.26	-.78401509	972.73386657
.4966213	58.5998	32.0421	76.7480	.01565	.00769	108.77	-.78281544	970.93403011
.5173209	59.6735	32.8962	96.7574	.00143	-.02468	194.86	-.77805857	963.79845020
.5381535	60.6643	33.1681	116.7699	.00414	-.02417	296.19	-.77336781	956.76394772
.5591263	61.6370	33.1682	136.7944	-.00500	-.00812	59.02	-.76873284	949.81500449
.5696725	62.0002	32.8898	146.7604	.00449	.00478	126.85	-.76644842	946.39080407
.5802435	62.4800	32.6903	156.7575	.01073	.02950	199.36	-.76417161	942.97847081
.5962169	63.2324	32.4986	171.7678	-.00246	.01996	285.57	-.76078047	937.89690789
.6069021	63.6929	32.4909	181.7751	.00801	-.00157	36.02	-.75853767	934.53670696
.6176134	64.1620	32.3808	191.7570	.03107	-.02577	119.86	-.75631481	931.20682613
.6389050	65.4556	31.8186	211.5183	.01453	-.00826	293.33	-.75195560	924.67799175
.6497266	66.1863	31.4376	221.5063	-.00721	-.01114	23.62	-.74977298	921.40973984
.6606040	66.7605	31.0158	231.5141	-.00108	-.01496	115.47	-.74759978	918.15604303
.6715911	67.4193	30.4433	241.5848	.00601	.00963	211.63	-.74542669	914.90294754
.6826361	68.1132	29.8984	251.6759	-.00703	.02487	309.83	-.74326290	911.66424159
.6934357	68.7458	29.4265	261.5059	-.00634	.00343	48.12	-.74116816	908.52933649
.7044443	69.1975	28.9631	271.4842	.00993	-.00195	140.27	-.73905490	905.36713553
.7100111	69.5092	28.6156	276.5211	.01740	-.00198	200.54	-.73799312	903.77849541
.7266517	70.4967	27.6864	291.5235	-.00329	-.00649	355.65	-.73485015	899.07663195
.7433621	71.3357	26.6441	306.5031	.01101	-.02714	155.94	-.73174083	894.42609386
.7602671	72.3732	25.3809	321.5918	-.00020	-.00717	319.99	-.72863763	889.78569222
.7771860	73.2666	24.0114	336.6146	.00386	-.01748	126.28	-.72557627	885.20882662
.7942154	74.1092	22.4214	351.6489	.00090	.00257	295.98	-.72254042	880.67108333
.8285609	75.8861	19.0460	381.7483	.00360	.00205	285.13	-.71654476	871.71210486
.8458100	76.8129	17.3367	396.7461	-.00060	-.02132	103.10	-.71359747	867.30955949
.8631711	77.1843	15.6008	411.7116	-.01078	-.01546	283.01	-.71068270	862.95652965
.9157734	80.0479	8.5093	456.8181	.01677	-.02378	110.34	-.70205213	850.07287805
.9335078	80.4724	5.7357	471.8530	.00974	-.00770	295.73	-.69922585	845.85567469
.9513351	81.1067	2.8412	486.8891	.00825	-.02594	122.75	-.69642403	841.67587224
.9691903	81.8521	-.0380	501.8618	.00475	.00356	310.83	-.69365822	837.55069968
1.0052403	83.2372	-5.8648	531.9188	.00289	.00363	329.43	-.68817760	829.37913395

TABLE 3.

SHOT 002

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.4032922	55.3436	32.6077	26.7526	.03472	-.07110	131.50	-.77573911	981.19681843
.4237402	55.9280	33.1221	46.7515	-.04681	.00109	164.88	-.77114715	974.07402809
.4340169	56.0873	33.2546	56.7299	-.05272	.02960	189.92	-.76887804	970.55512092
.4443361	55.9658	33.5348	66.7419	-.02592	.02802	218.30	-.76661584	967.04747359
.4494827	55.8978	33.7381	71.7183	-.00412	.01971	233.26	-.76549681	965.31256265
.4546784	55.8295	33.9017	76.7260	.02214	.00488	249.68	-.76437433	963.57242885
.4755362	55.9250	34.3911	96.7379	.05768	-.02465	318.45	-.75992416	956.67488620
.4965252	56.5517	34.4118	116.7447	-.02028	.02337	36.39	-.75553113	949.86803444
.5176479	56.9211	34.4959	136.7425	-.03830	.04309	122.63	-.75119500	943.15141682
.5282688	56.8767	34.6185	146.7359	-.01977	.01511	168.35	-.74904837	939.82709779
.5389126	56.8416	34.8322	156.7278	.00900	-.02349	215.13	-.74691538	936.52442382
.5549985	56.8319	34.8841	171.7549	.03696	-.05076	287.44	-.74373233	931.59681473
.5657554	56.9624	34.6781	181.7549	.03050	-.02648	337.17	-.74163045	928.34359099
.5765310	57.1356	34.2758	191.7364	.00526	.01439	28.81	-.73954534	925.11682027
.5979612	57.5770	33.6047	211.5032	-.02730	.04032	130.38	-.73545359	918.78621178
.6088492	57.6578	33.4735	221.4819	-.03312	.00250	185.55	-.73340668	915.62005534
.6197993	57.6898	33.2847	231.4898	-.00992	-.04171	240.06	-.73136622	912.46438302
.6308433	57.6403	33.0112	241.5583	.02060	-.05192	294.23	-.72932586	909.30937635
.6419614	57.6985	32.4844	251.6624	.03463	-.02611	350.59	-.72729074	906.16296919
.6528288	57.8019	31.7695	261.4873	.02163	.01344	46.81	-.72532371	903.12230820
.6638947	58.0972	31.1189	271.4654	-.00847	.04747	103.95	-.72333785	900.05303762
.6694972	58.1883	30.9012	276.5032	-.02922	.05211	133.11	-.72233972	898.51055122
.7030455	58.2126	29.5134	306.4897	.02062	-.05368	310.95	-.71646021	889.42705642
.7200507	58.2710	28.1845	321.5788	.03321	-.00925	43.72	-.71354100	884.91869026
.7370598	58.6877	26.8409	336.5962	-.01137	.03858	138.26	-.71066134	880.47249400
.7541900	58.8884	25.6590	351.6373	-.03125	-.00163	232.97	-.70780248	876.05948142
.7887173	58.9160	22.9017	381.7273	.04400	-.00501	65.97	-.70215803	867.34978052
.8060541	59.4064	21.3056	396.7262	-.00761	.01737	163.00	-.69938103	863.06630320
.8235036	59.7768	19.8935	411.7092	-.02983	-.01505	261.29	-.69663085	858.82523729
.8586715	60.1706	16.2387	441.7934	.02176	.00991	100.12	-.69117961	850.42196268
.8763321	60.7037	14.1856	456.7985	-.01020	-.01207	159.39	-.68849541	846.28573813
.8941532	61.0597	12.1789	471.8451	-.01197	-.03900	298.06	-.68582661	842.17424998
.9120390	61.2288	9.6729	486.8785	.01377	-.00715	36.98	-.68318266	838.10208168
.9299600	61.5823	7.1150	501.8505	.00566	.01938	133.94	-.68057160	834.08156977
.9480010	61.9713	4.7351	516.8013	-.01088	-.00300	231.23	-.67798595	830.10118596
.9661256	62.2082	2.2620	531.8941	.01528	-.03118	328.60	-.67539747	826.11745703

TABLE 3.

SHOT 008

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.0067591	55.6924	29.7364	6.7518	-.01788	.05905	288.79	-.63609719	997.86569964
.0269275	56.0264	30.9614	26.8138	.03127	-.04390	300.75	-.63209974	991.59995787
.0471560	56.8888	31.4698	46.8098	.00917	-.03527	314.97	-.62816511	985.43267325
.0675182	57.7619	31.3048	66.8131	-.02789	.04007	333.30	-.62427772	979.33945126
.0726083	57.8915	31.4265	71.7942	-.02907	.04957	338.01	-.62331718	977.83385921
.0777366	58.0082	31.4608	76.8050	-.02374	.04406	342.77	-.62235388	976.32395549
.0983051	58.4578	31.8563	96.8248	.01384	-.01930	3.42	-.61853472	970.33765769
.1189870	59.1138	31.8800	116.8319	.01814	-.03144	25.65	-.61476450	964.42808111
.1397897	59.9064	31.3058	136.8337	-.01162	.01764	48.80	-.61104092	958.59161752
.1607068	60.5942	30.8323	156.8242	-.00253	.01169	72.70	-.60736423	952.82863833
.1765055	60.8975	30.5571	171.8437	.01433	-.01768	92.43	-.60463078	948.54413185
.1870664	61.2255	30.2145	181.8462	.02285	-.03369	105.98	-.60282399	945.71210985
.1976484	61.6390	29.8439	191.8389	.01809	-.02658	119.24	-.60102972	942.89970564
.2186684	62.5095	28.7985	211.6005	-.00247	.01120	146.73	-.59751262	937.38686768
.2293397	62.9892	28.1732	221.5889	.00175	.01332	160.85	-.59575052	934.62489606
.2400699	63.1407	27.6920	231.6028	-.00446	.01241	175.46	-.59399432	931.87217071
.3214643	65.8878	22.2536	306.6243	.00233	.00212	291.57	-.58115946	911.75434401

TABLE 3. (CONCLUDED)

SHOT 009

T-SEC	Y-IN	Z-IN	X-FT	M	N	ϕ-DEG	C_{DT}	V-fps
.0067427	55.3078	29.5240	6.4769	-.00651	.02328	100.67	-.63592892	999.58394724
.0470775	56.2793	30.2815	46.8186	-.00438	-.00646	130.52	-.62819774	987.44702121
.0673925	56.7774	30.2882	66.8180	-.01087	.02324	154.66	-.62440904	981.49925955
.0724678	56.9144	30.3160	71.7957	.00223	.02019	161.66	-.62347315	980.03003292
.0775827	56.9776	30.3339	76.8047	.00541	.00975	168.36	-.62253419	978.55600411
.0981086	57.3508	30.3826	96.8302	.01933	-.01764	197.83	-.61880842	972.70704103
.1187378	57.9561	30.0084	116.8367	-.00744	.00384	230.83	-.61513043	966.93307804
.1290816	58.2926	29.7228	126.8236	-.01431	.01391	249.07	-.61331074	964.07640556
.1394863	58.4728	29.4453	136.8397	-.01434	.01342	268.03	-.61149650	961.22829497
.1498925	58.6610	29.2412	146.8277	-.00552	.00474	286.96	-.60969800	958.40489363
.1603351	58.8428	28.9847	156.8213	.00855	-.00934	306.50	-.60790905	955.59647169
.1760922	59.1601	28.4628	171.8456	.00930	-.01710	337.64	-.60523920	951.40516903
.1866228	59.4354	28.0421	181.8499	.00186	-.01080	358.53	-.60347438	948.63463292
.2181228	60.1621	26.4609	211.6030	-.00904	.00300	65.56	-.59828600	940.48956959
.2287473	60.3140	25.8012	221.5809	-.00027	-.00786	88.19	-.59656595	937.78931723
.2394546	60.6019	25.2309	231.6076	.01536	-.00677	111.88	-.59484741	935.09144333
.3205449	62.5543	18.9430	306.6271	.00636	-.00537	293.38	-.58229671	915.38851321

TABLE 4. VIPER AERODYNAMIC DATA

SHOT #	CONF	AVE M	P_{ss} DEG/FT	C_{D_T}	δ^2	C_{D_o}	Cm_α	$C_{mq} + C_{m\dot{\alpha}}$	C_{ℓ_p}	$C_{\ell_\delta}{}^{\delta}$	$C_{N\alpha}$	C_{Xo}	K_{TO} DEG	REMARKS
93	2	.830	2.80	.683	3.83	.679	-10.95	-438	-4.27	.027	7.54	.678	0.1	
94	2	.833	3.57	.684	0.59	.683	-12.67	-501	-6.60	.050	7.50	.682	0.9	Questional Angular Fit
95	2	.8177	3.64	.677	1.27	.676	-10.19	-430	-5.14	.038	7.42	.675	0.2	
96	3	.820	4.77	.687	3.30	.684	-21.78	-286	-15.73	.152	8.08	.685	0.1	Poor Roll Fit
97	3	.807	5.20	.685	1.74	.683	-18.78	-270	-7.03	.072	6.82	.683	0.2	
98	3	.798	3.38	.680	2.63	.677	-19.32	-219	---	---	6.40	.681	0.4	Poor Angle Fits - Could Not Fit Roll Adequately
99	12	.822	5.48	.717	0.76	.716	-30.49	-313	-6.14	.073	7.39	.716	0.7	Questionable Angular Fit
01	12	.822	12.26	.738	2.03	.736	-10.36	-309	-3.62	.092	4.84	.737	0.5	Damaged Fin
02	12	.792	6.52	.722	5.61	.716	-15.22	-451	-4.06	.053	8.48	.718	1.1	
08	7	.845	1.58	.614	4.33	.610	-13.27	-182	-3.15	.011	6.96	.607	0.2	
09	7	.850	2.50	.607	0.89	.607	-15.97	-185	-5.09	.027	6.24	.614	0.2	

NOTE: MREF 2, 3, and 7 .54L from nose
MREF 12 .5525L from nose

TABLE 5. DATA COMPARISON

	VOUGHT TEST	EGLIN TEST
CNα	6.30	7.42, 7.54
CMα	-8.45	-10.19, -10.95
CA	.46 (less base drag)	.68 (including base drag)
CL	.068	.032

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